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Styles of Crater Gradation in Southern Ismenius Lacus, Mars; J.A. Grant and P.H. Schultz, Brown University, Providence, RI 02912.

Introduction: Preserved morphology around selected impact craters together with results from study of longterm gradational evolution (1) are used to assess processes responsible for crater modification in southern Ismenius Lacus (30°–35°N, 325°–360°W). Results are compared with the gradational styles of selected terrestrial craters (2). Although most craters in the region display complex primary morphologies, some first order comparisons with the gradational styles around simple terrestrial craters may be valid (2). Nearly complete high resolution coverage (Revs 199S–212S, ~40–50 m/pixel) provides a basis for studying morphologic features at scales comparable to those observed in Landsat TM images of terrestrial craters (2). In addition, 816 craters >1–2 km in diameter within the study area were classified (Table 1) as degraded (rimless/mostly rimless, buried) pristine (most primary features present), and superpristine (unmodified at available resolution). Nearly 2/3 of the degraded craters are rimless/mostly rimless (Table 1). The average slope on the interior walls of both degraded and pristine craters is 27°–30° (Table 2), close to the angle of repose for material dominated by silt and sand-sized grains (3). The maintenance of these gradients into advanced degraded morphologies implies an abundance of fine-grained material in the country rocks. This statement is consistent with the low regional thermal inertia (4). Epochs of accelerated gradation affected southern Ismenius Lacus from early until mid/late Noachian and during the Hesperian (1). Widespread remnants of an air-fall deposit emplaced/modified during the second epoch are preserved in eastern sections of the region; however, more sustained erosion farther west left only isolated remnants (1). We conclude the relative importance of gradational processes differs around the terrestrial and martian craters considered here: martian rimless morphologies are produced by mass-wasting, eolian deposition/erosion, and limited fluvial incisement resulting in downwasting and significant backwasting of crater walls.

Discussion: Clues to the origin of degraded crater morphologies in the study area are found in the regional geologic history. Emplacement of air-fall deposits during the second gradational epoch smoothed crater topography, especially in eastern sections where buried morphologies are more common. However, uniform deposition on a cratered surface should preserve a raised-rim around larger craters (5,6). Thus, mantling alone can not conceal raised-rims. Subsequent erosion of air-fall deposits would proceed most rapidly on exposed crater walls and rim-crests. These exposed topographic highs would in turn act as a windbreak, thereby slowing deflation on surrounding lower gradient surfaces. Hence, air-fall deposition/partial removal could produce a rimless/mostly rimless morphology. The absence of air-fall deposits around some rimless/mostly rimless craters in the region requires additional rim removal mechanisms.

Some partially rimless craters display walls modified by catastrophic mass-wasting through failure of large wall sections (e.g. 32.7°N, 359.9°W). Because material derived from wall failure is not easily identified as landslide and debris flow deposits inside these craters, the mass-wasting deposits must be either reworked across the crater floor or removed. Low drainage densities observed on associated crater walls implies an analogy with the fluvial redistribution of material that occurs in terrestrial craters is unrealistic (7). If the target rocks are comprised largely of reworked ejecta and buried lenses of volatile-rich material with abundant fine-grained sediment (1,7), eolian redistribution of landslide and debris flow deposits could modify their appearance. Redistribution would proceed most rapidly during gradational epochs when atmospheric density may have been higher and carrying capacity was enhanced. In addition, air-fall deposition and subsequent erosion/redistribution further mask mass-wasting deposits.

Maintenance of constant slope angles throughout increasing degradation implies that a less catastrophic means of mass-wasting may contribute to raised-rim removal also. As the debris forming the crater walls is partially redistributed across the crater by eolian activity the resultant oversteepening would cause minor slumping, backwasting and restoration of the angle of repose. Dessica-

tion of possible water/ice-rich lenses exposed in crater walls (1,7) would also reduce wall strength, thereby inducing slumping.

In addition to craters where the surrounding ejecta has been modified by air-fall deposition/erosion, some retain ejecta only in near-rim areas. The greater thickness of near-rim ejecta around these craters may have trapped sufficient impact heat to cause partial welding of the fragments and/or may be composed of more competent lithologies, thereby enhancing preservation. Low drainage density and a paucity of recognizeable fluvial depositional features analogous to those observed around Meteor Crater (7) suggests that fluvial processes play a secondary role to eolian activity in erosion of the distal ejecta. Ejecta sedimentology at Meteor Crater implies martian ejecta and regolith has moderate to high hydraulic conductivity (7); therefore, the role by fluvial processes in over-all erosion of Martian craters may be limited in the absence of high magnitude precipitation events or widespread catastrophic groundwater release.

Gradational Evolution: As craters are formed in southern Ismenius Lacus they excavate material possessing abundant fine-grained material (sand and silt) and possibly containing lenses of water/ice (1,7). Shock preconditioned walls slump during the late stages of crater formation to ~27°–30° (Table 2). Reduced fluvial activity on the low gradient ejecta surfaces relative to the Earth causes eolian processes to become relatively more important during subsequent gradation. In some areas air-fall deposition simply buries ejecta while in others the distal ejecta is entirely stripped away. Surface lag deposits analogous to those observed at Meteor Crater (7) undoubtably slow deflation. Gradation at least sinc since Hesperian times occurs largely through mass-wasting and eolian processes rather than fluvial activity. Both catastrophic and slow, sustained backwasting of the interior wall and lowering of the rim-crest results in rim removal from up to 50% of the degraded craters. In many cases rim removal occurs without complete erosion of the continuous ejecta. Crater floor deposits created by mass-wasting are redistributed by eolian activity and/or are buried by later air-fall deposition. In contrast, gradation of selected simple terrestrial craters is dominted by slow, steady downwasting and backwasting of the rim by both fluvial and mass-wasting erosion (2,7). Comparison of degraded martian craters with pristine craters in the surrounding terrain and degraded craters on the Earth suggests destruction of the raised-rim by backwasting in Ismenius Lacus accounts for crater enlargement of ~10–15%. Air-fall deposition/erosion during late gradation also created rimless morphologies in ~15% of the craters (Table 1).

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Table 1 – Crater Classification in Southern Ismenius Lacus

General Classification	Number	% Total
Total Craters	816	100
Degraded	330	40
Pristine	417	51
Super Pristine	69	9
Degraded Craters		
Rimless – Mostly Rimless	104	32
Rimless – Mostly Rimless w/ Ejecta	50	15
Rimless – Mostly Rimless Buried	27	8
Rimless – Mostly Rimless Buried w/Ejecta	25	8
Partly Rimless w/Ejecta	20	6
Partly Rimless Buried w/Ejecta	11	3
Complete Rim	35	10
Other (Inverted, Ghost Craters)	5	2
Undifferentiated	53	16
Pristine Craters		
Pristine	361	87
Pristine Valley-Modified	56	13

Table 2 – Crater Wall Slopes in Southern Ismenius Lacus

	Measured Average	Range
Degraded Craters		
Rimless – Mostly Rimless	28°	17°–40°
Rimless – Mostly Rimless w/ Ejecta	29°	20°–36°
Rimless – Mostly Rimless Buried w/Ejecta	27°	—
Pristine Craters		
Pristine	27°	24°–35°
Pristine Valley-Modified	30°	25°–28°